A DESCRIPTIVE ANALYSIS OF WORD-INITIAL CLUSTERS PRODUCED BY PHONOLOGICALLY DISORDERED CHILDREN

By

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A DESCRIPTIVE ANALYSIS OF WORD-INITIAL CLUSTERS PRODUCED BY PHONOLOGICALLY DISORDERED CHILDREN

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Previous research has demonstrated that children acquire singleton consonants before they acquire consonant clusters. Further, it has been demonstrated that as children acquire consonant clusters, their productions differ in several ways from the adult. The most commonly reported cluster simplification pattern is cluster reduction, in which one or more of the segments is omitted. Several researchers have hypothesized that children progress through stages as they begin to approximate the correct adult cluster production. During this developmental period, various simplification patterns have been observed. Such patterns are a reflection of the child's current phonological capacity.

The purpose of this study was to document several cluster simplification patterns observed in phonologically disordered children. A word-elicitation task was administered to five white males (aged 4:2 to 5:4) diagnosed as phonologically disordered. The subjects were asked to produce 65 word-initial clusters and a corresponding set of words containing the singleton elements of the clusters. The frequency of occurrence of cluster reduction, within-cluster assimilation, epenthesis, and coalescence was reported. A comparison of singleton production to cluster production was also included.

It was found that all children exhibited cluster reduction and coalescence. The other patterns occurred to a lesser degree and with less consistency. In addition, four of the five children were found to produce some correct clusters. The more severely disordered subjects exhibited more instances of cluster reduction, suggesting that they were in earlier stages of development than the less severely disordered subjects. Comparisons of clusters to singletons provided information useful in coding the various simplification patterns. Suggestions and rationale regarding testing procedures were included. Implications for clinical practice and for further research were also provided.

CHAPTER I
INTRODUCTION AND REVIEW OF LITERATURE

Introduction

For the past 30 years, researchers have attempted to study phonological development in both normal and phonologically disordered children. Recent attempts have focused specifically on describing the development of cluster production and on describing the cluster deviations produced by children classified as phonologically deviant.

In general, it has been shown that normal children acquire singleton consonants before they acquire consonant clusters (Sander, 1972; Templin, 1957). Further, it has been demonstrated that as children acquire consonant clusters, their productions differ in several ways from the adult. For example, the most commonly occurring process is cluster reduction, in which one or more of the segments of the cluster is omitted (Grunwell, 1982).

Several researchers (Greenlee, 1974; Grunwell, 1982; Ingram, 1976) have suggested that children progress through various stages as they begin to approximate the correct adult production of clusters. The following stages are suggested as the most likely course of development for both normal and disordered phonological systems:

Stage 1: Cluster deletion,

Stage 2: Cluster reduction,

Stage 3: Cluster with inaccurate segment(s),

Stage 4: Correct cluster.

Such researchers assume that the order of the stages of cluster development is invariant. However, certain clusters are more likely to show specific stages of development (Greenlee, 1974; Grunwell, 1982). For instance, Hodson and Paden (1983) suggested that children with phonologically deviant systems will often display cluster deletion for both word-initial and word-final clusters. In normally developing children, cluster deletion is more common on word-final clusters. Further, this stage is more likely to occur in those children who also delete final singleton consonants (Ingram, 1976).

During the stage of cluster reduction, the omitted segments can be predicted in both normal and phonologically disordered children. For instance, in /s/ clusters, the /s/ is often deleted (Ingram, 1976). In stop plus liquid/glide or fricative plus liquid/glide clusters, the liquids and glides are more likely to be omitted (Greenlee, 1974; Grunwell, 1982; Ingram, 1976). During this stage of development, the child would be likely to produce [tʌk] instead of [trʌk].

Some researchers, e.g., Gilbert and Purves (1977), have suggested that, at this stage, children find the temporal constraints of cluster production difficult. Often, an epenthetic vowel or consonant is inserted between the two elements of the cluster (Hodson, 1986).

It is during the third stage of development that the process of coalescence may occur. Hodson (1986) defines coalescence as the replacement of two consonants by a consonant that has characteristics of both of the original phonemes. Thus, the word-initial cluster /sp/ may become [f] where the [f] has fricative qualities of the /s/ and labial characteristics of the /p/.

The third stage of cluster development also involves producing the cluster with some type of distortion or substitution occurring. Assimilation is a likely process to occur here. Within-cluster assimilation occurs when the expected elements of the cluster are replaced by two elements that are more like each other. For instance, /gl/ would be replaced by [bw]. Other frequent consonant substitutions, such as [t] for /k/ may also occur, resulting in [st] for /sk/.

Researchers have attempted to document the occurrence of the above patterns with respect to stages of development in both normal and phonologically disordered children (Dunn & Davis, 1983; Dyson, 1987; Dyson & Stewart, 1987; Schoenfeld, 1986). For children aged 4:0 to 6:0, the most commonly occurring cluster simplification process appears to be cluster reduction (Dunn & Davis, 1983). However, other researchers have also found coalescence, assimilation, and epenthesis to occur with greater frequency than previously thought.

The protocol utilized to examine word-initial and word-final clusters in children involves eliciting words containing the target cluster (Dyson & Stewart, 1987; Schoenfeld, 1986). However, little or no attempt has been made to compare the child's production of the clusters to his production of singletons. Such analysis could alter how the child's cluster production pattern is reported. For example, if a child continually substitutes [d] for /t/, then it would seem likely that in the word-initial cluster /tr/ the child would produce [dr].

The purpose of this investigation was two-fold. First, this descriptive study attempted to demonstrate the frequency of occurrence of the patterns of cluster reduction, within-cluster assimilation, epenthesis, and coalescence in a group of phonologically disordered children. Second, each child's word-initial clusters were compared to the child's word-initial singletons. The following question was posed:

> To what extent do children classified as phonologically disordered display coalescence, within-cluster assimilation, epenthesis, and cluster reduction?

Review of the Literature

Normal Acquisition of Consonant Singletons and Clusters

The literature regarding cluster production in both normal and phonologically deviant systems is both extensive and exhaustive. To fully understand the cluster deviations produced by children with phonologically disordered systems, it is important to first understand the acquisition of consonant clusters in normal children.

It is well known that children acquire single consonants before clusters (Templin, 1957). Generally, the vast majority of singletons are acquired by the age of 4:0. Some of the more difficult sounds such as /s/, /z/, /r/, /dʒ/, and /tʃ/ may not be acquired until as late as 8:0. Liquids, affricates, and some of the fricatives appear to be the most difficult to perfect. However, this age criterion differs among individual children. The appearance of clusters coincides with the acquisition of singletons. For example, most of the sounds and sound sequences produced in our language are perfected by the age of 5:0.

During phonological development, normal children utilize a variety of simplification processes. According to Stampe (1969), children simplify their production of words according to their current phonological capacity. For example, a child who has not yet acquired velar consonants may produce the word /kæt/ as [tæt]. This assimilation or harmony between the postvocalic and prevocalic consonant demonstrates that the child "knows" a sound must occur before the vowel. However, he is incapable of producing the velar consonant and thus uses a simplification process to produce the word he intended to say.

Simplification processes have also been found to occur in cluster production (Stoel-Gammon & Dunn, 1985). According to the suggested stages of cluster development (Greenlee, 1974; Grunwell, 1982; Ingram, 1976), simplification processes are expected to occur in Stage 2--Cluster reduction--and Stage 3--Production of a cluster with inaccurate segment(s). The most commonly reported process occurring is cluster reduction (Greenlee, 1974; Grunwell, 1982), where one or more of the elements of the cluster is omitted. It is much easier for a child to produce a singleton than it is a cluster. Therefore, a child may produce [tɑp] instead of /stɑp/. Dyson and Paden (1983) reported cluster reduction and deletion occurring in normal 2-year-olds. Often the retained segment was altered as occurs in assimilation or coalescence.

During the stage of production of a cluster with inaccurate segment(s), coalescence, within-cluster assimilation, and epenthesis are likely to occur. Hodson (1986) defined epenthesis as the insertion of a vowel or consonant between two consonants. The most common form of epenthesis is the insertion of the schwa /ə/ between the two elements of the cluster. Instead of producing /blu/, the child produces [bəlu].

Within-cluster assimilation occurs when the expected segments of the cluster are replaced by two segments that are more like each other than expected. For example, /gl/ could be replaced by [bw]. The segments in the second cluster production are more like each other in that they are both labial sounds. Grunwell (1982) reported evidence of within-cluster assimilation for /s/ clusters. For example, /swɪŋ/ was realized as [fwɪn] or [ɸwɪn].

Coalescence can be defined as the replacement of the two segments in a cluster by a single sound that has characteristics of both of the original phonemes. For example, the cluster /sp/ could become [f]. The single phoneme is a fricative, characteristic of the /s/, and is labial, characteristic of the /p/.

The acquisition of both singletons and clusters is a process restricted by the child's phonological inventory at the present stage of development. As the child begins to acquire more and more sounds and learns the rules of the language, the productions appear more adult-like and eventually represent the true adult productions.

Cluster Production in Phonologically Deviant Systems

Researchers have hypothesized that children with phonologically deviant systems progress through the same stages as do normal children (Ingram, 1976). That is, the order of the stages of cluster production is invariant. However, phonologically disordered children may remain in certain stages longer than do normal children. Studies have reported the existence of coalescence, assimilation, epenthesis, and cluster reduction (Greenlee, 1974; Grunwell, 1982; Ingram, 1976) but have not reported the actual frequency of occurrence of each pattern.

Investigations of phonologically disordered children (Hodson & Paden, 1983; Ingram, 1976) have revealed that these children do, in fact, delete both word-initial and word-final clusters (Stage I). However, this stage does not appear to extend over a long period of time. Rather, the stages of cluster reduction, substitution, and distortion appear to be most common.

Cluster reduction has been commonly reported in the literature (Dyson, 1987; Dyson & Stewart, 1987; Greenlee, 1974, Grunwell, 1982; Ingram, 1976). During this stage of development, children with phonologically disordered systems can be expected to show predictable cluster reductions. For example, in /s/ clusters, the /s/ is often deleted (Greenlee, 1974). In /s/ plus stop clusters (/sp/, /st/, and /sk/), it appears to be easier for the child to produce the stop than the fricative sound. Therefore, the /s/ is often omitted from the cluster. Research investigating the production of stops/fricatives plus liquids/glides (e.g., /fl/, /tw/, and /kr/) has demonstrated that children will usually delete the liquids or glides (Greenlee, 1974; Grunwell, 1982; Ingram, 1976). Because liquids are later developing singletons, one would expect that a phonologically deviant system would be incapable of correctly producing that sound and would thus have difficulty producing a cluster containing such a phoneme.

The temporal aspects of the cluster have also been investigated (Gilbert & Purves, 1977; Grunwell, 1982). It was found that the remaining segment of a reduced cluster is often lengthened, suggesting that the child recognizes the cluster in the adult form but is yet incapable of producing two consonants in sequence.

The occurrence of coalescence has also been reported in studies investigating clusters in phonologically deviant systems (Dyson, 1987; Dyson & Stewart, 1987; Grunwell, 1982). Grunwell (1982) termed coalescence "feature synthesis" because it involves producing a single consonant that has features of both of the original phonemes. It is hypothesized that at this stage of development the child understands that two consonants exist in the cluster. However, the child is still incapable of producing a sequence of two consonants and thus combines the characteristics of the original two phonemes into one.

Assimilation and epenthesis have also been described as commonly occurring simplification processes (Dyson, 1987; Dyson & Stewart, 1987; Edwards, 1971; Gilbert & Purves, 1977). Gilbert and Purves (1977) reported the existence of epenthesis as a timing problem in children. The "splitting process" occurs because the child is incapable of making the temporal constraints required by the cluster. In order for the child to correctly articulate both elements in the cluster, the epenthetic vowel is inserted between the consonants to allow the child sufficient time to correctly produce each phoneme. Such a production returns the CCV(C) syllable to the more basic or "natural" CV syllable shape (Edwards & Shriberg, 1983). Edwards (1971) described the acquisition of liquids in a child classified as phonologically disordered. Several instances of epenthesis were reported. Some examples include: *flower* ----> [fəlwaur], *green* ----> [gərin], and *dragon* ----> [dɔr æ̯gn̩].

Dyson (1987) described various occurrences of within-cluster assimilation in normally developing children. Assimilation was found to occur on a vast majority of /s/ and liquid/glide clusters. The clusters /kl/, /kr/, /br/, /sl/, /sw/ were realized as [fw], [pw], [øw], [fw], and [pw].

In 1987, Dyson and Stewart examined word-initial clusters in six phonologically disordered children. The single-word productions were elicited by pictures or in response to stimulus questions. Often, delayed imitation was utilized to evoke correct responses. Their results indicated that cluster reduction, coalescence, assimilation, and epenthesis did in fact occur in these children. Only 2% of the clusters were produced correctly. Cluster reduction was found to occur on 69% of the single words. Of those clusters reduced, 73% retained one segment, 21% were reported to involve coalescence, and 6% contained an unusual substitution. Clusters with substituted segments constituted 26% of the single words. Of these, 48% were expected substitutions, 41% contained some type of assimilation, and 11% were produced with epenthesis. Deleted clusters constituted 6% of the 360 possible clusters.

Current research suggests that the stages proposed by previous authors (Dyson, 1987; Greenlee, 1974; Grunwell, 1982; Ingram, 1976) do in fact exist. However, more investigations into the actual occurrence of the patterns observed in the developmental stages in both normal and phonologically disordered children is warranted.

Methodological Considerations

Previous research has focused on analyzing spontaneous speech samples as the best possible indicator of a child's true speech performance (Dyson & Stewart, 1987). Few would dispute this point. Most speech samples are obtained by asking children to name pictures, to speak on a topic of their choice, or to respond to questions or cues. At times, delayed imitation is utilized if the child does not know the target word.

No investigations have compared the child's cluster production to productions of the same sounds as singletons. Although Maxwell & Rockman (1984) suggested that word pairs such as spot and pot be included in a phonological assessment procedure. Because correct cluster production requires producing two phonemes correctly, it may be useful to examine the child's production of both of the singleton elements in the cluster. For example, if a child continually substitutes [b] for /p/, one would expect /p/ to be produced as [b] in the cluster. If for some reason this does not occur, it is a more reliable assumption that another phonological process affecting /p/ in clusters is occurring. This type of comparison would involve presenting the child with near minimal triples including the target cluster word, a word containing the first segment of the cluster, and a word containing the second segment of the cluster. For example, for the word-initial cluster /gr/ in grow words examining the singleton production could be rose and go. Such a procedure would allow the investigator to more accurately reach conclusions regarding the child's cluster production.

The descriptive study reported here examined word-initial clusters with particular attention to the four processes of cluster reduction, wtihin-cluster assimilation, coalescence, and epenthesis in five phonologically disordered children. The clusters were examined in reference to singleton production of both segments of the cluster.

CHAPTER II
METHODS AND PROCEDURES

Subjects

The subjects in this study were five males who met the following criteria.

1. They were between the ages of 4:2 and 5:4. The mean age was 4:9.
2. The children were all evaluated at the University of Florida Speech and Hearing Clinic (UFSHC), Gainesville, Florida and diagnosed as having phonological disorders.
3. The children all scored at least 40% occurrence of cluster reduction on the Assessment of Phonological Processes--Revised, APP-R (Hodson, 1986). The APP-R results summarized in Table 2-1 through 2-5.
4. An age-appropriate score was obtained on the Peabody Picture Vocabulary Test--Revised (Dunn & Dunn, 1981).
5. Hearing was within normal limits.

Experimental Speech Sample

The stimulus material used in this study was a word list generated by the examiner and adapted from Elbert and Gierut's (1986) generative phonology word list. The stimulus word list included the common initial clusters /gr/, /gl/, /kr/, /kl/, /dr/, /tr/, /st/, /sp/, /sk/, /sw/, /sm/, /sn/, and /sl/. In addition, a corresponding set of

Table 2-1. Phonological analysis summary from the APP-R for Subject 1 (C.A.= 4:2).

Basic Phonological Processes	Percent of Occurrence
Syllable Reduction	5
Consonant Sequence Reduction	58
Prevocalic Singleton Omission	2
Postvocalic Singleton Omission	48
Strident Deficiencies	42
Velar Obstruent Deficiencies	23
Liquid /l/ Deficiencies	27
Liquid /r/ Deficiencies	62
Nasal Deficiencies	37
Glide Deficiencies	30
Severity Interval Rating for Phonology	Profound

Table 2-2. Phonological analysis summary from the APP-R for Subject 2 (C.A.= 5:3).

Basic Phonological Processes	Percent of Occurrence
Syllable Reduction	26
Consonant Sequence Reduction	98
Prevocalic Singleton Omission	2
Postvocalic Singleton Omission	65
Strident Deficiencies	81
Velar Obstruent Deficiencies	100
Liquid /l/ Deficiencies	91
Liquid /r/ Deficiencies	100
Nasal Deficiencies	0
Glide Deficiencies	50
Severity Interval Rating for Phonology	Moderate

Table 2-3. Phonological analysis summary from the APP-R for Subject 3 (C.A.= 5:2).

Basic Phonological Processes	Percent of Occurrence
Syllable Reduction	0
Consonant Sequence Reduction	63
Prevocalic Singleton Omission	16
Postvocalic Singleton Omission	23
Strident Deficiencies	63
Velar Obstruent Deficiencies	9
Liquid /l/ Deficiencies	27
Liquid /r/ Deficiencies	86
Nasal Deficiencies	11
Glide Deficiencies	20
Severity Interval Rating for Phonology	Moderate

Table 2-4. Phonological analysis summary from the APP-R for Subject 4 (C.A.= 4:2).

Basic Phonological Processes	Percent of Occurrence
Syllable Reduction	5
Consonant Sequence Reduction	63
Prevocalic Singleton Omission	11
Postvocalic Singleton Omission	23
Strident Deficiencies	60
Velar Obstruent Deficiencies	91
Liquid /l/ Deficiencies	100
Liquid /r/ Deficiencies	81
Nasal Deficiencies	0
Glide Deficiencies	10
Severity Interval Rating for Phonology	Severe

Table 2-5. Phonological analysis summary from the APP-R for Subject 5 (C.A.= 5:4).

Basic Phonological Processes	Percent of Occurrence
Syllable Reduction	5
Consonant Sequence Reduction	60
Prevocalic Singleton Omission	0
Postvocalic Singleton Omission	6
Strident Deficiencies	21
Velar Obstruent Deficiencies	14
Liquid /l/ Deficiencies	64
Liquid /r/ Deficiencies	100
Nasal Deficiencies	5
Glide Deficiencies	20
Severity Interval Rating for Phonology	Severe

single words was elicited in which the phonemes represented in the initial cluster appeared as initial singletons. These words were minimal or near minimal triples. For example, goat, grow, and rose constituted a near minimal triple. See Appendix A for the entire word list. The purpose of the near minimal triples was to examine the child's production of singletons in reference to the two phonemes present in the cluster. Five words containing initial clusters were represented for each cluster examined, e.g., /gr/. Accordingly, ten words (five representing the first segment of the cluster, e.g., /g/, and five representing the second segment, e.g., /r/) were utilized to examine the singleton productions.

Procedures

Each subject was administered the Assessment of Phonological Processes--Revised, APP-R (Hodson, 1986) in an initial evaluation prior to elicitation of the experimental speech sample. Based upon this score and hearing found to be within normal limits, the child was asked to return for a second evaluation. Letters of consent were obtained from those subjects who had not attended the University of Florida Speech and Hearing Clinic prior to the initial evaluation.

Each subject was seen for approximately one hour in a treatment room at the University of Florida Speech and Hearing Clinic for the second visit. The Peabody Picture

Vocabulary Test--Revised (Dunn & Dunn, 1981) was administered to screen language abilities. Next, each subject was asked to produce the single-word experimental list from the picture cards. Some words were elicited by delayed imitation or in response to cues or questions. The picture cards were used to elicit single words, and toys were present to facilitate spontaneous conversation. The subjects' productions were audio-recorded on a TEAC V-350C Stereo Cassette Deck with a Sansui Stereo Amplifier A-501 using a Realistic PZM Microphone placed on the table in front of the child.

Phonetic Transcription

Each session was transcribed at a later date using a consensus transcription procedure developed by Shriberg, Kwiatkowski, and Hoffman (1984). To ensure validity and interscorer reliability, two independent listeners (Dr. Alice T. Dyson and the experimenter) transcribed each word. They then compared their transcripts and obtained consensus for disagreements by replaying the stimulus word in question a maximum of three times. After the replays and the second transcription, if consensus was reached, the transcribers advanced to the next word. If the listeners still did not agree, they applied one of the 17 consensus rules recommended by Shriberg et al. (1984).

Data Analysis

Each child's response on both clusters and singletons was noted. Each attempt to produce a cluster was coded according to response definitions devised by the experimenter. See Table 2-6 for response code definitions. If two categories seemed to apply as in /sp/ ----> [s͜t], the cluster was coded according to the most salient feature affecting correct cluster production as the feature judged to be farthest from the adult model. In this instance, the cluster would be coded as CS, cluster substitution, because substituting [t] for /p/ affected cluster production more than did lateralization of /s/.

The percentage of occurrence of coalescence, within-cluster assimilation, epenthesis, and cluster reduction was computed. The coded data were sorted and analyzed using the PC-File+ (Button, 1988) database software program.

Table 2-6. Response code definitions used to score cluster attempts.

Response Code	Definition
CC	Correct cluster production
CA	Cluster but within-cluster assimilation from one segment to the other as in /sw/ ----> [pw]
CS	Cluster but with one or both segments replaced by an incorrect segment (substitution), no obvious assimilation
CD	Cluster with no obvious assimilation, one or both segments distorted
CE	Cluster with epenthetic vowel inserted between segments
CF	Reduced to one segment having features of expected segments as in /sp/ ----> [f] (coalescence)
R	Reduced to one segment, no coalescence
O	Entire cluster deleted

CHAPTER III
RESULTS

Phonological analysis summaries from the APP-R (Hodson, 1986) for each subject were presented in Tables 2-1 through 2-5. Each child received an overall consonant sequence reduction score of 40% or greater (58% to 98%). This would indicate that the subjects were unable to produce many consonant clusters. The clusters analyzed in the APP-R occur in a variety of positions within words. However, the position of the cluster did not affect performance on the word-elicitation task used in this study because only word-initial clusters were examined. Interesting to note are the other phonological process that occur with at least 40% frequency of occurrence. These could have affected the child's ability to produce clusters.

Subject 1 displayed a consonant sequence reduction score of 58%. Other phonological processes occurring with greater than 40% frequency of occurrence were postvocalic singleton omission 48%, strident deficiencies 42%, and liquid /r, ɝ/ deficiencies 62%.

Subject 2 displayed a consonant sequence reduction score of 98%. Virtually all of his cluster productions were in error. Other phonological processes occurring with greater than 40% frequency of occurrence were postvocalic singleton omission 65%, strident deficiencies 81%, velar obstruent deficiencies 100%, liquid /l/ deficiencies 91%, liquid /r, ɝ/ deficiencies 100%, and glide deficiencies 50%. This subject was the most severely impaired and exhibited cluster reduction on almost every word in the word-elicitation task.

Subject 3 displayed a consonant sequence reduction score of 63%. Other phonological processes occurring with greater than 40% frequency of occurrence were strident deficiencies 63% and liquid /r, ɝ/ deficiencies 86%. Subject 4 also displayed a consonant sequence reduction score of 63%. Other phonological processes occurring for this subject were strident deficiencies 60%, velar obstruent deficiencies 91%, liquid /l/ deficiencies 100%, and liquid /r, ɝ/ deficiencies 81%.

Finally, Subject 5 displayed consonant sequence reductions with a frequency of occurrence score of 60%. Other phonological processes occurring with greater than 40% frequency of occurrence were liquid /l/ deficiencies 64%, and liquid /r, ɝ/ deficiencies 100%.

The percentage and number of occurrences of phonological patterns studied for each subject can be found in Table 3-1. The total number of word-initial clusters elicited was 65. Cluster reduction was the most commonly occurring process, ranging from 97% of the clusters produced for Subject 2 to 31% for Subject 1. Only Subject 3 exhibited cluster deletion in which the entire cluster was omitted. This occurred on

Table 3-1. Percentage and number of occurrences of phonological patterns (number of possible occurrences = 65).

Phonological Pattern		Subject 1	2	3	4	5
correct cluster	%	17	0	19	3	9
	#	11	0	12	2	6
cluster distortion	%	11	0	6	2	11
	#	7	0	4	1	7
within-cluster assimilation	%	11	2	0	9	0
	#	7	1	0	6	0
cluster substitution	%	19	0	20	9	22
	#	12	0	13	6	14
cluster reduction	%	31	97	37	37	46
	#	20	63	24	24	30
epenthesis	%	8	0	9	0	0
	#	5	0	6	0	0
coalescence	%	5	2	6	40	12
	#	3	1	4	26	8
cluster deletion	%	0	0	3	0	0
	#	0	0	2	0	0

only two occasions. Instead of producing [sm], no sound segments occurred for this subject on this particular cluster in the words smile and smell.

Four of the five subjects produced some clusters correctly. The frequency of occurrence of correct clusters ranged from 3% for Subject 4 to 17% for Subject 1. Interestingly, only two subjects exhibited epenthesis. This pattern occurred only 6 times for Subject 3 and only 5 times for Subject 1. One would have expected more instances of epenthesis to occur because all of these children are in the stage of producing incorrect along with correct clusters.

Clusters produced with some type of alteration of one of the segments constituted a vast majority of the phonological patterns observed. Four of the five subjects produced cluster substitution in which one of the segments in the cluster was replaced by another sound. Often a voiceless /p/ was replaced by [b] and /t/ was replaced by [d]. Other commonly occurring substitutions were [w] for /l/ and /r/. The frequency of occurrence of cluster substitution ranged from 9% for Subject 4 to 22% for Subject 5. Cluster distortion also occurred for four out of the five subjects. In this instance, both the segments of the cluster were produced; however, one of the segments was produced with some type of distortion. This often occurred in producing /s/ clusters, with the /s/ often palatized or lateralized. Voiceless sounds were sometimes produced with an excessive amount of aspiration or voicing distorting the cluster somewhat. The frequency of occurrence of cluster distortion ranged from 2% for Subject 4 to 11% for Subjects 1 and 5. Within-cluster assimilation, however, only occurred for three of the five subjects. Subject 2 displayed 1 instance of this pattern and Subjects 4 and 1 exhibited within-cluster assimilation 6 and 7 times respectively. For the actual child's productions, see Appendix B.

In general, Subject 2 displayed the most severe phonological pattern because 97% of his initial cluster productions were reduced to one segment. He only exhibited one instance each of coalescence and within-cluster assimilation. The second sound segment of the cluster was almost always omitted and the first segment was replaced by a different sound. For example, for all the /dr/, /gl/, and /gr/ clusters, he produced [d]. For all the /kl/ and /kr/ clusters, he produced [t]. A possible coalescence occurred on one of the /kr/ clusters, produced as [p]. Because [w] was consistently produced for /r/ in the singleton productions, we can say that coalescence has occurred because his cluster production would be expected to be [kw] for /kr/. Thus, the [p] has stop characteristics of the /k/ and labial features of the /w/. Within-cluster assimilation occurred for one instance of the initial cluster /tr/. Again, based on singleton productions, we would expect this child to produce [tw]. Instead, he produced [βw], categorized as assimilation because both sounds are now labial in place of articulation.

The remaining four subjects produced clusters with various phonological patterns. Approximately 30-40% of their initial cluster productions were reduced to one segment. Distorted and substituted clusters were also produced by these children. However, only two of the four produced within-cluster assimilation, and one subject exhibited two instances of cluster deletion. Correct cluster productions also occurred for these subjects. Subjects 1 and 3 exhibited a high percentage of correct clusters, 17% and 19% respectively.

Interestingly, all five subjects exhibited patterns of coalescence. Almost half (40%) of Subject 4's initial clusters were defined as coalescence. The remaining subjects exhibited this pattern to a lesser extent, ranging from 2% to 12%. Coalescence became easier to define after examination of singleton productions as in the case of Subject 2 described above. Examples of coalescence include /sm/ ----> [f], /sw/ ----> [f], /dr/ ----> [b], and /tr/ ----> [tʃ].

In summary, cluster reduction and coalescence were the only phonological patterns found in all subjects. Cluster reduction was the most commonly occurring pattern overall. Epenthesis only occurred in two out of the five subjects and within-cluster assimilation in only three out of the five subjects. Correct clusters were produced by four of the subjects, and only one subject exhibited cluster deletion.

CHAPTER IV
DISCUSSION

Conclusions

Several researchers have hypothesized that children progress through various stages as they acquire consonant clusters (Greenlee, 1974; Grunwell, 1982; Ingram, 1976). Four stages have been proposed as the normal course of development. These range from Stage 1 (cluster deletion) to Stage 4 (correct cluster). It is assumed that the order of progression is invariant. Phonologically disordered children then, should also progress through these stages but may do so at a much slower rate.

Cluster deletion, the first stage and presumably the shortest stage in terms of duration occurs at an early age. Dyson and Paden (1983) found that normal 2-year-olds exhibited instances of cluster deletion. In the present study, only one subject, aged 5:2, displayed two instances of cluster deletion, both on [sm].

As noted earlier, cluster reduction is a commonly reported process within the available literature regarding phonological development. It has been demonstrated to exist in both normal and phonologically disordered children. Ingram (1976) hypothesized that cluster reduction is exhibited in Stage 2 of cluster development.

The subjects in this study all exhibited instances of cluster reduction. In fact, the vast majority of their cluster productions could be included in this reduction pattern.

Ingram (1976) demonstrated that in clusters containing /s/, the /s/ is often deleted. This was observed to be true in this sample. In /s/ clusters, the /s/ was often deleted and the second segment (usually a stop) was produced. For example, /spa͡ɪ/ was often realized as [pa͡ɪ]. Researchers have demonstrated that other predicted patterns of reduction can occur (Greenlee, 1974; Grunwell, 1982; Ingram, 1974). For example, in stop plus liquid/glide, the liquid or glide is likely to be omitted. Therefore, one would expect the /r/ to be deleted in /r/ clusters. Examples of this did frequently occur in this subject sample. For instance, /græb/ was realized as [dæp] by one subject. This is in accordance with results from the APP-R (Hodson, 1986) because many of the subjects displayed significant liquid /r/ deviations. Therefore, the children had difficulty producing /r/ in a cluster as well as in singletons.

Gilbert and Purves (1977) have suggested that at this stage of development temporal constraints may affect the child's ability to produce clusters correctly. Often an epenthetic vowel is inserted between the two elements of the cluster. Epenthesis was found to occur in only two subjects and with relatively low frequencies. It may be that the children in this study did not have any difficulty in the temporal mapping of clusters. They understood that two sound segments were expected; however, for other reasons were incapable of producing them correctly.

The third stage of development, production of a cluster with inaccurate segment(s), was found to occur for all children in this study. However, not all expected phonological patterns occurred for each subject. Coalescence has been reported in the literature as occurring in phonologically deviant systems (Dyson, 1987; Dyson & Stewart, 1987; Grunwell, 1982). Interestingly, all the subjects in this study exhibited instances of coalescence. It has been hypothesized that the child understands that two consonants exist in the cluster but is incapable of producing both sounds. Therefore, he combines features of those sounds into one sound segment. Examples exhibited by the children in this study include: /kr/ ----> [p], /sm/ ----> [f], /sw/ ----> [f], and /st/ ----> [tʃ].

Within-cluster assimilation is also expected to occur during this stage of development. However, only three of the five subjects exhibited this phonological pattern. For example, /tr/ was replaced by [βw]. Cluster distortion and cluster substitution were more common, occurring in four out five subjects. The substitutions and distortions noted were typically those commonly reported for disordered phonological systems, e.g., /k/ ---> [t], /l/ ----> [w], and /s/ ----> [s̪]. These cluster simplification patterns have also been well documented in the literature (Dyson, 1987; Dyson & Stewart, 1987; Edwards, 1971; Gilbert & Purves, 1977).

Even though the children were characterized as severely phonologically disordered, four out of five subjects exhibited some correct clusters. These most commonly were stop plus liquid/glide clusters (e.g., [tr], [gl], [gr], and [dr]). One subject produced correct /s/ plus nasal/stop/liquid clusters. Examples included [sm], [sn], [sp], and [sw].

In summary, it appears that of the phonological patterns observed, cluster reduction and coalescence were the most commonly occurring patterns in that they occurred in all subjects. Consistent with previous literature, cluster reduction constituted the majority of most of the children's observed phonological patterns. Interestingly, coalescence also occurred for each subject but to a much lesser extent. One subject exhibited a greater frequency of coalescence than cluster reduction. Dyson and Stewart (1987) have suggested that this pattern may not be restricted to phonologically disordered children but may be exhibited by normally developing children as well.

The other processes of within-cluster assimilation, substitution, distortion, and deletion occured but to varying degrees for each subject. For example, one subject displayed 97% cluster reduction and only one instance each of coalescence and assimilation. The remaining subjects produced the various phonological patterns with varying frequency. On average, the various patters of within-cluster assimilation, distortion, and substitution ranged from 2% to 20%. Correct clusters were also observed, indicating that as the children acquire correct production of more singletons, correct cluster production will follow.

Methodological Considerations

It is well known that consonant singletons develop before clusters (Sander, 1972; Templin, 1957). Inclusion of the APP-R (Hodson, 1986) as a baseline measure of a child's phonological performance is important. A child who scores in the severe range on consonant sequence reduction will obviously display cluster production difficulties. However, examining their performance on other phonological processes also allows the examiner to predict which clusters may present a problem for the child. For example, a child exhibiting a high frequency of occurrence of liquid deviations can be expected to have difficulty with inital /l/ and /r/ clusters.

The degree of severity of the consonant sequence reduction score can also prove helpful to the examiner.

For example, a child exhibiting 90% frequency of occurrence of consonant sequence deviations might be expected to be in the early stages of cluster development. Therefore, he would exhibit mainly cluster reduction and occasional patterns including correct consonant segments. In fact, this occurred in this particular sample of children. The less severe the score, the more phonological patterns occurred, indicating the child was attempting correct cluster production.

The use of near minimal triples in research is also an important factor. It is impossible to accurately examine the frequency of occurrence of phonological cluster patterns without examining the child's singleton production in reference to that cluster. For example if a child produces [p] for /kr/, one might call this cluster reduction. However, if one examines singleton production of both /k/ and /r/, the pattern may seem different. If the child continually substitutes [w] for /r/, then the above example would be considered coalescence because the [p] has features of the stop /k/ and features of the labial /w/ sounds.

Implications for Further Research

It is obvious that examining the developmental sequence of any behavior is complex. However, examining the occurrence of phonological patterns is both feasible and necessary. Future research should involve comparisons of normal children in terms of age and sex with phonologically disordered children to examine the possible correlates of frequency of occurrence of the above mentioned phonological patterns. The use of referent singletons should continue to be utilized as this aids the examiner in understanding the child's cluster productions.

Knowledge concerning severity and extent of exhibited patterns can aid the clinician in interpreting results of tests and in better targeting cluster production in remediation. For example, extremely severe performances on tests, such as the APP-R, can predict expected phonological patterns in terms of the various stages of development. Future research comparing standard test results to frequency of occurrence of expected phonological patterns will also be beneficial to understanding the cluster production exhibited by phonologically disordered children.

APPENDIX A
EXPERIMENTAL WORD LIST

/gr/

goat	grow	rose
gas	grass	ran
gate	grape	rain
gas	grab	ran
geese	green	read

/gl/

gum	glove	lunch
gas	glass	laugh
goose	glue	loop
guide	glide	lie
go	globe	lobe

/kr/

cake	crayon	radio
candy	cracker	rabbit
kite	cry	ride
cow	crown	round
call	crawl	wrong

/kl/

cob	clock	lock
key	clean	leaf
coat	clothes	loaf
cow	clown	loud
cat	clap	laugh

/dr/

desk	dress	red
dive	drive	ride
dog	draw	wrong
duck	drum	run
door	drawer	roar

/tr/

tail	train	rain
teeth	tree	read
tub	truck	run
tick	trick	rip
tank	trash	ran

/st/

soap	stove	toes
sorry	star	tar
sock	stop	top
song	store	tore
sack	stand	tank

/sp/

soup	spoon	pool
sail	space	paint
sign	spy	pipe
sign	spider	pipe
sit	spill	pig

/sk/

soup	school	cool
sail	skate	cake
seal	ski	key
sign	sky	kite
sun	skunk	cup

/sw/

sit	swing	wing
seal	sweep	wheel
sell	sweater	web
sock	swat	watch
sit	swimming	wing

/sm/

sign	smile	mine
sell	smell	men
sack	smash	man
soup	smooth	moon
song	small	mall

/sn/

sew	snow	nose
sail	snail	nail
sail	snake	nail
soup	Snoopy	new
seal	sneeze	knee

/sl/

seal	sleep	leaf
sign	slide	light
sail	sleigh	lake
sew	slow	loaf
sack	slap	laugh

APPENDIX B
PHONETIC TRANSCRIPTION OF WORDS FROM ELICITATION TASK

WORD	TYPICAL ADULT PRODUCTION	SUBJECT 1	SUBJECT 2	SUBJECT 3	SUBJECT 4	SUBJECT 5
desk	/dɛsk/	[dɛk]	[dr] [dɛs̪]	[dɛs͡k]	[dɛt]	[dɛs̪]
dress	/drɛs/	[d̥wæs]	[dɛʔ]	[drɛʂ]	[dʒæt]	[bɛs̪]
red	/rɛd/	[wɛː]	[wɛ͡ə]	[ᵊwæ]	[wɛd̥]	[wæd]
dive	/da͡ɪv/	[da͡ɪ]	[da͡ɪ]	[da͡ɪv]	[da͡ɪ]	[da͡ɪv]
drive	/dra͡ɪv/	[d̥rʷa͡ɪ]	[da͡ɪ]	[t̽ra͡ɪf]	[dʒa͡ɪv̥]	[ba͡ɪv]
ride	/ra͡ɪd/	[wa͡ɪ]	[ʰwa͡ɪ]	[wa͡ɪd]	[wa͡ɪd]	[wa͡ɪd]
dog	/dɔg/	[dɔ]	[dɔ͡ə]	[dɔg̥]	[dɔt]	[dɑg̥]
draw	/drɔ/	[drɔ]	[dɑ]	[dʒɔ]	[drɔ]	[ba͡ʊ]
wrong	/rɔŋ/	[wɔ̃]	[wɔŋ]	[wɔ̃]	[wɑn]	[wɔn]
duck	/dʌk/	[dʌk]	[dʌʔᵊ]	[dʌk]	[dʌt]	[dʌk]
drum	/drʌm/	[dʒʌm]	[dʌm]	[drʌm]	[dʒʌm]	[bʌn]
run	/rʌn/	[wʌn]	[wʌn]	[wʌn]	[wʌn]	[wʌn]
door	/dɔ͡ɚ/	[dɔ]	[do͡ʊ]	[do͡ʊ]	[dɔ͡ə]	[dɔ]
drawer	/drɔwɚ/	[drɔ]	[do͡ʊ]	[dʒɔ]	[dʒɔ͡ə]	[dɔ]
roar	/rɔ͡ɚ/	[wɔwə]	[wo͡ʊ]	[wɔ]	[wɑː]	[wɔ]

WORD	TYPICAL ADULT PRODUCTION	SUBJECT 1	SUBJECT 2	SUBJECT 3	SUBJECT 4	SUBJECT 5
			[tr]			
tail	/te͡ɪl/	[te͡ɪʊ]	[t͡ɛʊ]	[te͡ɪʊ]	[te͡ɪo]	[t̬̿ e͡ɪʊ]
train	/tre͡ɪn/	[trẽ͡ɪ]	[te͡ɪn]	[trẽ͡ɪ]	[tʃre͡ɪn]	[pe͡ɪn]
rain	/re͡ɪn/	[we͡ɪ]	[we͡ɪŋ]	[we͡ɪn]	[weɪn]	[we͡ɪn]
teeth	/tiθ/	[tit]	[tiʔ]	[tɪs̯]	[kiʔ]	[tif]
tree	/tri/	[tri]	[ti]	[tri]	[tʃi]	[s̯wi]
read	/rid/	[hwi]	[rʷid]	[wid]	[wid̥]	[wid̥]
tub	/tʌb/	[tʌ]	[tʌḅ]	[tʌb̥]	[tʌp]	[dʌ]
truck	/trʌk/	[trʌk]	[βwʌʔ]	[tsřʷʌk]	[tʃrʌt]	[tskwʌ]
run	/rʌn/	[wʌn]	[wʌn]	[wʌn]	[wʌn]	[wʌn]
tick	/tɪk/	[tɪ]	[tɪʔ]	[tɪk]	[tɪ]	[kɪk]
trick	/trɪk/	[tɪk]	[tɪk]	[trɪk]	[ʃɪʔ]	[tʃɪk]
rip	/rɪp/	[wɪp]	[wɪp]	[wɪp]	[wɪp]	[wɪp]
tank	/tæŋk/	[˜̥ ẽ͡ɪ]	[te͡ɪʔ]	[tæŋk]	[tẽ͡ɪnt]	[de͡ɪŋk]
trash	/træʃ/	[træ]	[t͡æə]	[træʃ]	[tʃræ]	[p̬æs]
ran	/ræn/	[wæ]	[wæn]	[wæn]	[we͡ɪjən]	[wæn]

WORD	TYPICAL ADULT PRODUCTION	SUBJECT 1	2	3	4	5
			[kl]			
cob	/kɑb/	[kɔː]	[tɑp]	[kɑb̥]	[tɑp]	[k̬⁼ɑb]
clock	/klɑk/	[klɑ]	[tɑʔ]	[klɑk]	[trɑt]	[kɑk]
lock	/lɑk/	[lɑp]	[wɑʔ]	[lɑk]	[jɑt]	[lɑk]
key	/ki/	[ki]	[ti]	[ki]	[ti]	[ki]
clean	/klin/	[k͓lĩ]	[tin]	[klin]	[tʃin]	[kin]
leaf	/lif/	[lif]	[wi]	[lif]	[jif̬]	[lif]
coat	/ko͞ʊt/	[ko͞ʊt]	[to͞ʊt]	[ko͞ʊt]	[to͞ʊt]	[ko͞ʊt]
clothes	/klo͞ʊz/	[k͓͜slo͞ʊ]	[to͞ʊʷə]	[klo͞ʊʃ]	[tʃo͞ʊ]	[ko͞ʊz]
loaf	/lo͞ʊf/	[lo͞ʊf]	[wʊf]	[lo͞ʊf]	[jo͞ʊʔ]	[lo͞ʊf]
cow	/ka͞ʊ/	[ka͞ʊ]	[ta͞ʊ]	[ka͞ʊ]	[ta͞ʊ]	[kja͞ʊ]
clown	/kla͞ʊn/	[kɔla͞ʊ]	[ta͞ʊn]	[kla͞ʊ]	[tʃa͞ʊnᵈ]	[ka͞ʊn]
loud	/la͞ʊd/	[la͞ʊ]	[ba͞ʊ]	[la͞ʊd]	[ja͞ʊt]	[la͞ʊd̥]
cat	/kæt/	[kæt]	[tæʔ]	[kæt]	[tæʔ]	[kæt]
clap	/klæp/	[klæp]	[tæp]	[klæp]	[tʃæp]	[kæp]
laugh	/læf/	[læf]	[wæf]	[læf]	[jæʔ]	[læf]

WORD	TYPICAL ADULT PRODUCTION	SUBJECT 1	2	3	4	5
			[kr]			
cake	/ke͡ɪk/	[kɛk]	[te͡ɪʔ]	[ke͡ɪt˺]	[te͡ɪʔ]	[ke͡ɪk̬]
crayon	/kre͡ɪən/	[ɸwe͡ɪjɑ̃]	[tɛ͡ən]	[kwe͡ɪən]	[tʃe͡ɪjən]	[kwa͡ʊːn]
radio	/re͡ɪdɪo/	[we͡ɪdəgwo͡ʊ]	[we͡ɪdɪo]	[we͡ɪdɪo]	[we͡ɪʔɪo]	[wædɪo]
candy	/kændi/	[kæni]	[tæni]	[kændi]	[tæni]	[kjændi]
cracker	/krækɚ/	[kwækʊ]	[pæʔɚ]	[kwækʊs̡]	[tʃætrɔ]	[kwækʊ]
rabbit	/ræbɪt/	[wæbɪt]	[wæbʊ]	[wæbɪt˺]	[wæbɪt]	[wæbɪt]
kite	/ka͡ɪt/	[ka͡ɪt]	[ta͡ɪʔ]	[ka͡ɪt]	[ta͡ɪt]	[ka͡ɪt]
cry	/kra͡ɪ/	[kwa͡ɪ]	[tɛ͡a͡ɪ]	[k͓wa͡ɪ]	[tra͡ɪ]	[k͓wa͡ɪ]
ride	/ra͡ɪd/	[wa͡ɪ]	[ʰwa͡ɪ]	[wa͡ɪd]	[wa͡ɪd]	[wa͡ɪd]
cow	/ka͡ʊ/	[ka͡ʊ]	[ta͡ʊ]	[ka͡ʊ]	[ta͡ʊ]	[kja͡ʊ]
crown	/kra͡ʊn/	[kwa͡ʊ̃]	[ta͡ʊ̃]	[kwa͡ʊ̃]	[ʃæjən]	[kwa͡ʊn]
round	/ra͡ʊnd/	[wa͡ʊ]	[wa͡ʊ̂]	[wa͡ʊnd]	[wa͡ʊnd]	[wa͡ʊn]
call	/kɔl/	[kɔli]	[tɔ͡ə]	[kɔ]	[tɔ]	[kɔl]
crawl	/krɔl/	[kwɔ]	[tɔ͡ə]	[kwɔ]	[třɔ]	[kwʌ]
wrong	/rɔŋ/	[wɔ̃]	[wɔŋ]	[wɔ̃]	[wɑn]	[wɔn]

WORD	TYPICAL ADULT PRODUCTION	SUBJECT 1	2	3	4	5
			[gl]			
gum	/gʌm/	[gʌm]	[dʌm]	[gʌm]	[dʌm]	[g̥ʌm]
glove	/glʌv/	[gəlʌːb]	[d͡ʊə]	[glʌf]	[trʌv̥]	[g̥ʌz]
lunch	<NOT ELICITED>					
gas	/gæs/	[gæs̺]	[dæs]	[gæs̡]	[dʒᵊæ]	[gæs̺]
glass	/glæs/	[gəlæ]	[dæ]	[gəlæs̡]	[dʒæ]	[gjæs̺]
laugh	/læf/	[læf]	[wæf]	[læf]	[jæʔ]	[læf]
goose	/gus/	[gutʃ]	[dʒʊs̡]	[guʃ]	[dutʃ]	[kus]
glue	/glu/	[gəlu]	[du]	[gəlu]	[dʒu]	[ku]
loop	/lup/	[lup]	[wup]	[əlup]	[jup]	[lup]
guide	/ga͡ɪd/	[da͡ɪ]	[da͡ɪ]	[ga͡ɪd]	[da͡ɪd̥]	[g̥a͡ɪd]
glide	/gla͡ɪd/	[gla͡ɪ]	[da͡ɪ]	[gəla͡ɪd]	[dʒᵊa͡ɪd]	[ga͡ɪd]
lie	/la͡ɪ/	[la͡ɪ]	[wa͡ɪ]	[la͡ɪ]	[ja͡ɪ]	[la͡ɪ]
go	/go͡ʊ/	[go͡ʊ]	[do͡ʊ]	[go͡ʊ]	[do͡ʊ]	[kʰo͡ʊ]
globe	/glo͡ʊb/	[glo͡ʊ]	[do͡ʊb̥]	[gəlo͡ʊb̥]	[dʒo͡ʊb]	[ko͡ʊb˺]
lobe	/lo͡ʊb/	[lo͡ʊ]	[wo͡ʊp]	[lo͡ʊb̥]	[jo͡ʊb̥]	[lo͡ʊb]

WORD	TYPICAL ADULT PRODUCTION	SUBJECT 1	2	3	4	5
goat	/go͞ʊt/	[go͞ʊp]	[gr] [do͞ʊʔ]	[go͞ʊʔ]	[do͞ʊt]	[ko͞ʊt]
grow	/gro͞ʊ/	[g̥wo͞ʊ]	[do͞ʊ]	[gwo͞ʊ]	[ʒo͞ʊ]	[kwo͞ʊ]
rose	/ro͞ʊz/	[wo͞ʊ]	[rʷo͞ʊ]	[wo͞ʊzʲ̊]	[wo͞ʊ]	[wo͞ʊẓ]
gas	/gæs/	[gæs̪]	[dæs]	[gæs̡]	[dʒᵊæ]	[gæs̪]
grass	/græs/	[gwæː]	[dæ]	[grʷæs]	[dʒæ]	[g̥wæs]
ran	/ræn/	[wæ]	[wæn]	[wæn]	[we͞ɪjən]	[wæn]
gate	/ge͞ɪt/	[ge͞ɪt]	[de͞ɪʔ]	[ge͞ɪt]	[de͞ɪt]	[ge͞ɪt]
grape	/gre͞ɪp/	[gwe͞ɪp]	[de͞ɪp˺]	[gwe͞ɪp˺]	[gre͞ɪ]	[gwe͞ɪp]
rain	/re͞ɪn/	[we͞ɪ]	[we͞ɪŋ]	[we͞ɪn]	[we͞ɪn]	[we͞ɪn]
gas	/gæs/	[gæs̪]	[dæs]	[gæs̡]	[dʒᵊæ]	[gæs̪]
grab	/græb/	[grʷæ]	[dæp]	[gwæːp]	[dʒæp]	[g̥ræːp]
ran	/ræn/	[wæ]	[wæn]	[wæn]	[we͞ɪjən]	[wæn]
geese	/gis/	[gitʃ]	[diʔ]	[gis̡]	[ditʃ]	[g̥is]
green	/grin/	[gwĩ]	[din]	[gwin]	[dʒin]	[gwin]
read	/rid/	[hwi]	[rʷid]	[wid]	[wid̥]	[wid̥]

WORD	TYPICAL ADULT PRODUCTION	SUBJECT 1	2	3	4	5
soup	/sup/	[s̪up]	[sp] [hup]	[s̡up]	[ʃup]	[tsup]
spoon	/spun/	[p̬˭u]	[p̬˭u]	[pũ]	[pun]	[spun]
pool	/pul/	[pu]	[pu]	[pu]	[puː]	[pu]
sail	/se͞ɪl/	[se͞ɪʊ]	[he͞ʊ]	[se͞ɪə]	[ʃe͞ɪo]	[s̪e͞ɪo]
space	/spe͞ɪs/	[p̬e͞ɪ]	[p˭e͞ɪʔ]	[pe͞ɪs̯]	[pe͞ɪt]	[p̬e͞ɪs̪]
paint	/pe͞ɪnt/	[h̃e͞ɪmp]	[pe͞ɪnʔ]	[pe͞ɪnt]	[pe͞ɪnt]	[p̬˭e͞ɪnt]
sign	/sa͞ɪn/	[s̪a͞ɪ]	[ha͞ɪn]	[sa͞ɪn]	[tʃa͞ɪn]	[sa͞ɪn]
spy	/spa͞ɪ/	[ba͞ɪ]	[p̬˭a͞ɪ]	[pa͞ɪ]	[pa͞ɪ]	[pa͞ɪ]
pipe	/pa͞ɪp/	[pa͞ɪp]	[pa͞ɪʔ]	[pa͞ɪp]	[pa͞ɪp]	[pa͞ɪp]
sign	/sa͞ɪn/	[s̪a͞ɪ]	[ha͞ɪn]	[sa͞ɪn]	[tʃa͞ɪn]	[sa͞ɪn]
spider	/spa͞ɪdɚ/	[ba͞ʊwɚ]	[ba͞ɪʔʊ]	[pa͞ɪdʊ]	[pa͞ɪjʊ]	[pa͞ɪdoʊ]
pipe	/pa͞ɪp/	[pa͞ɪp]	[pa͞ɪʔ]	[pa͞ɪp]	[pa͞ɪp]	[pa͞ɪp]
sit	/sɪt/	[s̡ɪʔ]	[hɪʔ]	[s̡ɪt]	[ʃɪt]	[sɪt]
spill	/spɪl/	[bɪ͞ʊ]	[p̬˭ɪ͞ə]	[pɪ͞ʊ]	[pjɪ͞ʊ]	[pɪ͞ɚ]
pig	/pɪg/	[pɪ͞ə]	[pɪ͞ɚ]	[pɪg̊]	[pɪd]	[p̬˭ɪg]

WORD	TYPICAL ADULT PRODUCTION	SUBJECT 1	SUBJECT 2	SUBJECT 3	SUBJECT 4	SUBJECT 5
			[st]			
soap	/so͡ʊp/	[θo͡ʊp̚]	[ho͡ʊp]	[s̢o͡ʊp]	[ʃo͡ʊp]	[s̼o͡ʊp]
stove	/sto͡ʊv/	[ʃto͡ʊ]	[do͡ʊ]	[to͡ʊṿ]	[to͡ʊv̥]	[t̬˭o͡ʊv]
toes	/to͡ʊz/	[to͡ʊ]	[to͡ʊwə]	[to͡ʊs̢]	[to͡ʊ]	[to͡ʊs̪]
sorry	/sɑri/	[s̢ɑʔwi]	[hɔʔi]	[sɔwi]	[ʃɑʔi]	[s̪ɑwi]
star	/stɑ͡ɚ/	[dɔ]	[t̬˭ɔː]	[tɑ͡ə]	[tɔː]	[ts̪tɑ͡ʊ]
target	/tɑ͡ɚgət/	[tɑwɔgı]	[tɔʔə]	[tɑ͡ʊgət]	[tɔʔıt]	[t̬ɑgˌt]
sock	/sɑk/	[s̢ɑp̚]	[hɔʔ]	[s̢ɑk͓]	[ʃɑk]	[sɑk̚]
stop	/stɑp/	[ʃtɑp]	[t˭ɑp]	[tɑp]	[tɑp]	[tʃɑp]
top	/tɑp/	[t p]	[t p]	[t p]	[t p]	[t p]
song	/sɔŋ/	[s̪ɔ̃]	[hɔŋ]	[s̢ɔŋ]	[s̢ɔn]	[sɑ͡ʊŋᵏ]
store	/stɔ͡ɚ/	[dɔ]	[t̬˭o͡ʊ]	[tɔ]	[tɔ͡ə]	[tɔ]
tore	/tɔ͡ɚ/	[tɔ]	[tɔ]	[tɔ]	[tɔ͡ə]	[tɔ]
sack	/sæk/	[s̪æk]	[hæʔ]	[s̢æk]	[s̢jæt]	[sæk]
stand	/stænd/	[s̪tæ̃]	[t̬˭æn]	[tænd̥]	[tæn]	[t̬˭ænd]
tank	/tæŋk/	[˜̥ ẽ͡ɪ]	[te͡ɪʔ]	[tæŋk]	[tẽ͡ɪnt]	[de͡ɪŋk]

WORD	TYPICAL ADULT PRODUCTION	SUBJECT 1	 2	 3	 4	 5
			[sk]			
soup	/sup/	[s̪up]	[hup]	[s̡up]	[ʃup]	[tsup]
school	/skul/	[kut]	[du]	[kuː]	[tu]	[ku]
cool	/kul/	[ku]	[tu]	[ku]	[tuː]	[ku]
sail	/se͡ɪl/	[se͡ɪʊ]	[he͡ʊ]	[se͡ɪɚ]	[ʃe͡ɪo]	[se͡ɪo]
skate	/ske͡ɪt/	[k̬⁼e͡ɪt]	[t̬⁼e͡ɪʔ]	[ke͡ɪt]	[te͡ɪt]	[k̬⁼e͡ɪtʃ]
cake	/ke͡ɪk/	[kɛk]	[te͡ɪʔ]	[ke͡ɪt˺]	[te͡ɪʔ]	[k̬e͡ɪk]
seal	/sil/	[si͡ʊ]	[hi͡ʊ]	[sɪ͡ɚ]	[ʃɪ͡ʊ]	[si͡ʊ]
ski	/ski/	[k̬⁼i]	[t⁼i]	[ki]	[ti]	[ki]
key	/ki/	[ki]	[ti]	[ki]	[ti]	[ki]
sign	/sa͡ɪn/	[s̪a͡ɪ]	[ha͡ɪn]	[sa͡ɪn]	[tʃa͡ɪn]	[sa͡ɪn]
sky	/ska͡ɪ/	[k̬a͡ɪ]	[t̬⁼a͡ɪ]	[ka͡ɪ]	[ta͡ɪ]	[ka͡ɪ]
kite	/ka͡ɪt/	[ka͡ɪt]	[ta͡ɪʔ]	[ka͡ɪt]	[ta͡ɪt]	[ka͡ɪt]
sun	/sʌn/	[tsʌ̃]	[hʌn]	[ʃʌn]	[ʃʌn]	[tsʌn]
skunk	/skʌŋk/	[gʌŋk]	[t̬⁼ʌn]	[kʌŋk]	[tʌnt]	[s̯kʌŋk]
cup	/kʌp/	[tɑp]	[tʌp]	[kʌp]	[tʌp]	[kʌp]

WORD	TYPICAL ADULT PRODUCTION	SUBJECT 1	 2	 3	 4	 5
sign	/sa͡ɪn/	[s̪a͡ɪ]	[sm] [ha͡ɪn]	[sa͡ɪn]	[tʃa͡ɪn]	[sa͡ɪn]
smile	/sma͡ɪl/	[sæmʊ]	[ma͡ɪʔʊ]	[a͡ɪjʊ]	[~̥a͡ʊ]	[sma͡ɪʊ]
mine	/ma͡ɪn/	[ma͡ɪ]	[ma͡ɪn]	[ma͡ɪn]	[ma͡ɪn]	[ma͡ɪn]
sell	/sɛl/	[s̪e͡ɪ]	[hɛ͡ʊ]	[s̡ɛ]	[s̡ɛ]	[sɛ͡ʊ]
smell	/smɛl/	[ɸwɪ͡ʊ]	[mʊ͡ə]	[a͡ʊ]	[~̣ɛ͡ʊ]	[ts͜mɛ͡ʊ]
men	/mɛn/	[mɛ͡ə̃]	[mɪn]	[mʌn]	[mɛn]	[mɪn]
sack	/sæk/	[s̪æk]	[hæʔ]	[s̡æk]	[s̡jæt]	[sæk]
smash	/smæʃ/	[fmæ]	[mæ]	[ʃmæ̃s̡]	[hæ]	[mæs̭]
man	/mæn/	[mæ̃ː]	[mɛ͡ən]	[mæn]	[me͡ɪən]	[mæn]
soup	/sup/	[s̪up]	[hup]	[s̡up]	[ʃup]	[tsup]
smooth	/smuð/	[ʃʊmuː]	[muv]	[~̥ʊ̃ː ʒ̊]	[h̃uv̥]	[s͜muv̥]
moon	/mun/	[mũ]	[mun]	[mun]	[mun]	[m̃ɪ͡ʊn]
song	/sɔŋ/	[s̪ɔ̃]	[hɔŋ]	[s̡ɔŋ]	[s̡ɔn]	[sa͡ʊŋ ^{k}]
small	/smɔl/	[ɸwɔ̃]	[mɔː]	[s̡ɔ̃]	[hɔ]	[h̬ma͡ʊ]
mall	/mɔl/	[mɔ]	[mɔ]	[mɔ]	[mɑː]	[mɔ]

WORD	TYPICAL ADULT PRODUCTION	SUBJECT 1	2	3	4	5
			[sn]			
sew	/so͞ʊ/	[s̪o͞ʊ]	[ho͞ʊ]	[sɑ]	[ʃ o͞ʊ]	[s̪o͞ʊ]
snow	/sno͞ʊ/	[ʃ o͞ʊ]	[no͞ʊ]	[sjo͞ʊ̃]	[to͞ʊ]	[no͞ʊ]
nose	/no͞ʊz/	[no͞ʊ]	[no͞ʊ]	[no͞ʊz̢]	[no͞ʊ]	[no͞ʊz̥]
sail	/se͞ɪl/	[se͞ɪʊ]	[he͞ʊ]	[se͞ɪə]	[ʃe͞ɪo]	[se͞ɪo]
snail	/sne͞ɪl/	[ʃ e͞ɪʊ]	[he͞ɪʊ]	[ʃe͞ɪ̃jʊ]	[˜̥e͞ɪo]	[ts̢ne͞ɪʊ]
nail	/ne͞ɪl/	[n ɛ͞ʊ]	[ne͞ɪʊ]	[ne͞ɪʊ]	[ne͞ɪʊ]	[n ɛ͞ʊ]
sail	/se͞ɪl/	[se͞ɪʊ]	[he͞ʊ]	[se͞ɪə]	[ʃe͞ɪo]	[se͞ɪo]
snake	/sne͞ɪk/	[s̢e͞ɪk]	[ne͞ɪʔ]	[s̢je͞ɪ̃k]	[˜̥e͞ɪ ʔ]	[s͜ne͞ɪk]
nail	/ne͞ɪl/	[n ɛ͞ʊ]	[ne͞ɪʊ]	[ne͞ɪʊ]	[ne͞ɪʊ]	[n͡ ɛ͞ʊ]
soup	/sup/	[s̪up]	[hup]	[s̢up]	[ʃup]	[tsup]
Snoopy	/snupi/	[s̢ʌpʷi]	[mʊʔi]	[s̢jupi]	[˜̣nu̬pi]	[s͜nupi]
new	/nu/	[nu]	[nju]	[nu]	[nu]	[nu]
seal	/sil/	[si͞ʊ]	[hi͞ʊ]	[sɪ͞ə]	[ʃɪ͞ʊ]	[si͞ʊ]
sneeze	/sniz/	[tsĩ]	[ni]	[ṡ̃ĩz]	[hi]	[sni]
knee	/ni/	[ni]	[ni]	[ni]	[ni]	[ni]

WORD	TYPICAL ADULT PRODUCTION	SUBJECT 1	2	3	4	5
			[sl]			
seal	/sil/	[si͞ʊ]	[hi͞ʊ]	[sɪ͞ə]	[ʃɪ͞ʊ]	[si͞ʊ]
sleep	/slip/	[s̯lip]	[hip]	[ʃɪp]	[ʃip]	[s̯ˑip]
leaf	/lif/	[lif]	[wi]	[lif]	[jif̬]	[lif]
sign	/sa͞ɪn/	[s̪a͞ɪ]	[ha͞ɪn]	[sa͞ɪn]	[tʃa͞ɪn]	[sa͞ɪn]
slide	/sla͞ɪd/	[s̯la͞ɪ]	[ha͞ɪ]	[ts̡a͞ɪd˺]	[ʃa͞ɪd]	[s̪a͞ɪ]
light	/la͞ɪt/	[la͞ɪt]	[wa͞ɪʔ]	[la͞ɪt]	[ja͞ɪt]	[la͞ɪt]
sail	/se͞ɪl/	[se͞ɪʊ]	[he͞ʊ]	[se͞ɪɔ]	[ʃe͞ɪo]	[se͞ɪo]
sleigh	/sle͞ɪ/	[s̯le͞ɪ]	[he͞ɪ]	[s̡e͞ɪ]	[ʃe͞ɪjʊ]	[se͞ɪ]
lake	/le͞ɪk/	[le͞ɪk]	[we͞ɪʔ]	[le͞ɪk]	[ʒʲe͞ɪt]	[le͞ɪk]
sew	/so͞ʊ/	[s̪o͞ʊ]	[ho͞ʊ]	[sɑ]	[ʃo͞ʊ]	[s̪o͞ʊ]
slow	/slo͞ʊ/	[s̯lo͞ʊ]	[ho͞ʊ]	[sᵊwo͞ʊ]	[ʃo͞ʊ]	[so͞ʊ]
loaf	/lo͞ʊf/	[lo͞ʊf]	[wʊf]	[lo͞ʊf]	[jo͞ʊʔ]	[lo͞ʊf]
sack	/sæk/	[s̪æk]	[hæʔ]	[s̡æk]	[s̡jæt]	[sæk]
slap	/slæp/	[θæp]	[hæp]	[s̡æp]	[ʃæp]	[sæp]
laugh	/læf/	[læf]	[wæf]	[læf]	[jæʔ]	[læf]

WORD	TYPICAL ADULT PRODUCTION	SUBJECT 1	2	3	4	5
			[sw]			
sit	/sɪt/	[s̡ɪʔ]	[hɪʔ]	[s̡ɪt]	[ʃɪt]	[sɪt]
swing	/swɪŋ/	[ɸwĩ]	[hɪŋ]	[s̡wɪŋ]	[ɸwɪŋ]	[wɪŋᵏ]
wing	/wɪŋ/	[wi]	[wɪŋ]	[wɪŋ]	[wɪnᵊ]	[wɪŋᵏ]
seal	/sil/	[si͡ʊ]	[hi͡ʊ]	[sɪ͡ə]	[ʃɪ͡ʊ]	[sɪ͡ʊ]
sweep	/swip/	[ɸip]	[hip]	[s̡ip]	[s͡wip]	[swip]
wheel	/wil/	[wi͡ʊ]	[wi]	[wi͡ʊ]	[wi͡ʊ]	[wi͡ʊ]
sell	/sɛl/	[s̪e͡ɪ]	[hɛ͡ʊ]	[s̡ɛ]	[s̡ɛ]	[sɛ͡ʊ]
sweater	/swɛɾɚ/	[fɛʃɚ]	[hɛʔʊ]	[sɛdə]	[ɸwɛʔʊ]	[wɛɾʊ]
web	/wɛb/	[wɛ͡ə]	[wɛb̥]	[wɛb]	[wɛb]	[wɛb]
sock	/sɑk/	[s̡ɑp̚]	[hɔʔ]	[s̡ɑk͓]	[ʃɑk]	[sɑk̚]
swat	/swɑt/	[ʃfæk]	[hɑs̡]	[s̡ᵊwɑt]	[hwɑt]	[swɑp]
watch	/wɑtʃ/	-----	[wɑs]	[wɑtʃ]	-----	[wɑtʃ]
sit	/sɪt/	[s̡ɪʔ]	[hɪʔ]	[s̡ɪt]	[ʃɪt]	[sɪt]
swimming	/swɪmɪŋ/	[ɸwĩwĩ]	[hɪmɪŋ]	[tswɪmɪŋ]	[ɸwɪmɪn]	[swɪmɪn]
wing	/wɪŋ/	[wi]	[wɪŋ]	[wɪŋ]	[wɪnᵊ]	[wɪŋᵏ]

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a thesis for the degree of Master of Arts.

Alice T. Dyson

Alice T. Dyson, Chair
Assistant Professor of Speech

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a thesis for the degree of Master of Arts.

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This thesis was submitted to the Graduate Faculty of the Department of Speech in the College of Liberal Arts and Sciences and to the Graduate School and was accepted as partial fulfillment of the requirements for the degree of Master of Arts.

May, 1989

Dean, Graduate School